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(54) Air gap device for toroidal linear motor.

(57) An apparatus for adjusting air gap in a toroidal type linear motor which includes a moving element (28) having a cylindrical through opening and a stationary element (38) received in the cylindrical through opening, and in which the moving element is so movable as to maintain a predetermined annular air gap between the stationary and moving elements, said apparatus comprising a supporting member which is fixed to the moving element and which is so arranged as to separate from the stationary element by a predetermined distance when the predetermined annular air gap is maintained.

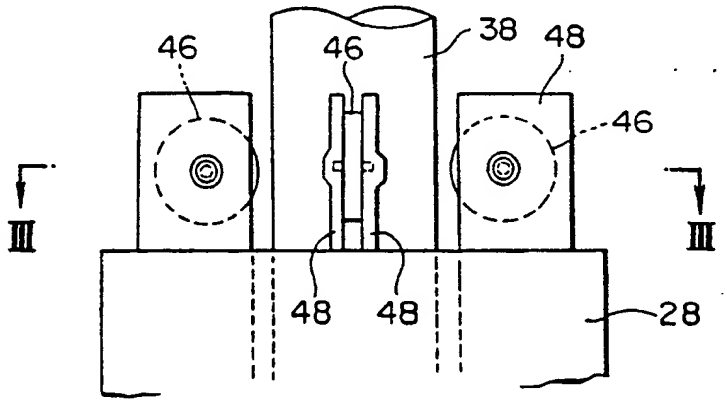

FIG. 2

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The present invention relates to an apparatus for adjusting air gap in a toroidal type linear motor which drives an elevator and so forth.

As is well known, a toroidal type linear motor comprises a moving element having a cylindrical through opening and a stationary element received in the moving element. The moving element is so movable as to maintain a predetermined annular air gap between the stationary and moving elements due to magnetic force produced therebetween.

In typical elevators driven by such a toroidal type linear motor, a vertically extending column fixed to a building is used as the stationary element, and the moving element incorporated in a counterweight is designed to be movable vertically. Sheaves are rotatably fixed to the upper portion of the building, and guide ropes. One end of each of the ropes is connected to the counterweight, and the other end thereof is connected to an elevator car. While the elevator car moves upwards and downwards, substantially even magnetic force usually exerts between the column and the moving element, so that a predetermined air gap is maintained between the column and the moving element. However, when the elevator car is stopped, no magnetic force exerts between the column and the moving element, so that the air gap can not be maintained. In addition, when an impact or vibration is applied to the column, the air gap can not be maintained. Therefore, in some of conventional elevators driven by a toroidal type linear motor, a plurality of rollers are rotatably fixed to the top and bottom surfaces of the moving element, and these rollers rotate and move on the column so that the predetermined air gap is maintained.

However, in such elevators, noise tends to occur due to rotation of the rollers while the elevator car moves upwards and downwards. In particular, since a plurality of columns are connected to each other to form a long column, noise occurs at the connecting points therebetween, so that the occupants within the elevator car enclosure can not obtain comfortableness.

It is therefore an object of the present invention to provide an apparatus for adjusting air gap in a toroidal type linear motor, which apparatus can maintain a predetermined air gap between a moving element and a column and can also decrease noise while an elevator car moves upwards and downwards.

In order to accomplish the aforementioned object, the present invention provides an apparatus for adjusting air gap in a toroidal type linear motor which includes a moving element having a cylindrical through opening and a stationary element received in the cylindrical through opening, and in which the moving element is so movable as to maintain a predetermined annular air gap between the stationary and moving elements, the apparatus comprising a supporting member which is fixed to the moving element and which is so arranged as to separate from the stationary element by a predetermined distance when the predetermined annular air gap is maintained. The supporting member may comprise a plurality of rollers which are rotatably provided on the top and bottom of the moving element, and the rollers may be so arranged as to be radially in relation to the stationary element. The distance between the stationary element and each of the rollers is preferably less than the distance between the stationary and moving elements. Alternatively, the supporting member may comprise an annular member fixed to the top and bottom surfaces of the moving element. In this case, preferably, the annular member has a cylindrical through opening, the inner diameter of which is greater than the outer diameter of the stationary element and is less than the inner diameter of the through opening of the moving element.

While even magnetic force exerts between the moving and stationary elements, a predetermined annular air gap is usually maintained therebetween, so that the supporting member is not brought into contact with the stationary element at all, thereby no noise occurs due to contact of the supporting member with the moving element. When uneven or no magnetic force exerts between the moving and stationary elements, or when an impact or vibration is applied to the stationary element, the supporting member comes into contact with the stationary element so as to prevent a portion of the air gap from decreasing below a predetermined value.

Referring now to the drawings, a preferred embodiment of the present invention is described below.

Fig. 1 schematically illustrates an elevator driven by a linear motor. As shown in Fig. 1, a pair of supporting shafts 10 are arranged on the upper portion of a building and extend in parallel to each other at a predetermined distance. Each of the supporting shafts 10 is provided with a pair of sheaves 12 which are arranged in parallel to each other and which are rotatably supported on the supporting shaft 10. Four ropes 14 are guided by these sheaves 12. One end of each of the ropes 14 is connected to an elevator car 16, and the other end thereof is connected to a counterweight unit 18. Therefore, when the elevator car 16 moves upwards, the counterweight 18 moves downwards, and when the elevator car 16 moves downwards, the counterweight moves upwards.

On both sides of the elevator car 16, a pair of guide rails 20 fixed to the building extends vertically in parallel to each other, so that the elevator car 16 is guided along the guide rails 20 via sliding members 22 or rollers provided on the side walls of

the elevator car 16.

The counterweight 18 comprises a frame 24 having an essentially rectangular section, and a weight 26 supported on the frame 24. As will be described hereafter, a moving element 28, a braking device 30 and so forth are also supported on the frame 24. The total weight of the counterweight 18 including these parts supported thereon is usually set to be 1.5 times of that of the elevator car 16.

On both sides of the counterweight 18, a pair of guide rails 32 extends vertically in parallel to each other. The top end of the guide rail 32 is fixed to the building by means of a top supporting beam 34, and the bottom end thereof is fixed to the building. Sliding members 36 or rollers are provided on the side walls of the counterweight 18, so that the counterweight 18 is guided along the guide rails 32 via the sliding members 36.

A toroidal type linear motor which serves as a driving source of the elevator comprises an aluminum alloy column (stationary element) 38 serving as a secondary conductor, and the toroidal moving element 28 serving as a primary conductor.

The column 38 extends vertically. The top end of the column 38 is fixed to the top supporting channel 34 via a column supporting member 40, and the bottom end thereof is fixed to the building via a column supporting member 42 and a bottom fixing portion 44.

The moving element 28 has a cylindrical through opening which extends in a direction of the axis thereof, and which receives the column 38 therein. As is well known, in toroidal type linear motors, a predetermined annular air gap is formed between the stationary and moving elements due to magnetic force produced therebetween. Therefore, as shown in Figs. 2 through 5, the moving element 28 is designed to move vertically so as to maintain a predetermined air gap L_1 between the outer surface of the column 38 and the inner surface of the through opening of the moving element 28.

When substantially even magnetic force does not exert between the column 38 and the moving element 28, or when an impact or vibration is applied to the column 38, the moving element 28 may not be parallel to the column 38, so that the predetermined air gap can not be maintained. In order to maintain the predetermined air gap, four rollers 46 are provided on each of the top and bottom of the moving element 28.

According to the first preferred embodiment of the present invention, the rollers 46 are rotatably supported between a pair of supporting plates 48 which project from the top and bottom surfaces of the moving element 28, and are so arranged as to separate from the column 38 by a predetermined distance L_2. Therefore, when a portion of the air gap between the moving element 28 and the column 38 is decreased, the rollers 46 come into contact with the column 38 so as to prevent the air gap from becoming less than the distance L_2. In addition, since the rollers 46 are separated from the column 38 by the predetermined distance L_2 when even magnetic force exerts between the moving element 28 and the column 38, it is possible to decrease noise produced by rotation of the roller 46, compared with conventional apparatus in which the roller 46 is always brought into contact with the column 38.

Figs. 4 and 5 illustrate a second preferred embodiment of an apparatus for adjusting air gap in a toroidal linear motor, according to the present invention. In this embodiment, an annular member 50 is substituted for the rollers 46. In this case, the inner diameter of the through opening 50a of the annular member 50 is greater than the outer diameter of the column 38, and is less than the inner diameter of the through opening 28a of the moving element 28.

As set forth above, according to the present invention, since the rollers fixed to the moving element are so arranged as to separate from the column by a predetermined distance when a predetermined annular air gap is maintained between the moving element and the column, the rollers do not always rotate and move on the column while the elevator car moves upwards and downwards. Therefore, it is possible to prevent noise produced by rotation of the rollers from occuring, and to prevent the air gap from decreasing below a predetermined value. In addition, in cases where the annular member is substituted for the rollers, the inner diameter of the through opening of the annular member is greater than the outer diameter of the column and is less than inner diameter of the through opening of the moving element. Therefore, the annular member does not come into contact with the column at all while even magnetic force exerts between the moving element and the column. Accordingly, it is possible to prevent noise from occuring, and prevent the air gap from decreasing below a predetermined value.

Fig. 1 is a schematic view of an elevator driven by a linear motor, according to the present invention;

Fig. 2 is a view illustrating a first preferred embodiment of an apparatus for adjusting air gap in the linear motor used for the elevator of Fig. 1;

Fig. 3 is a sectional view taken along the line III-III of Fig. 2;

Fig. 4 is a second preferred embodiment of an apparatus for adjusting air gap in the linear motor used for the elevator of Fig. 1; and

Fig. 5 is a sectional view taken along the line

V-V of Fig. 4.

Claims

1. An apparatus for adjusting air gap in a toroidal type linear motor which includes a moving element having a cylindrical through opening and a stationary element received in the cylindrical through opening, and in which the moving element is so movable as to maintain a predetermined annular air gap between the stationary and moving elements, said apparatus comprising a supporting member which is fixed to the moving element and which is so arranged as to separate from the stationary element by a predetermined distance when the predetermined annular air gap is maintained.

2. An apparatus as set forth in claim 1, wherein said supporting member comprises a plurality of rollers which are rotatably provided on the top and bottom of the moving element, and said rollers are so arranged as to be radially in relation to the stationary element.

3. An apparatus as set forth in claim 2, wherein the distance between the stationary element and each of the rollers is less than the distance between the stationary and moving elements.

4. An apparatus as set forth in claim 1, wherein said supporting member comprises an annular member fixed to the top and bottom surfaces of the moving element, and said annular member has a cylindrical through opening, the inner diameter of which is greater than the outer diameter of the stationary element and is less than the inner diameter of the through opening of the moving element.

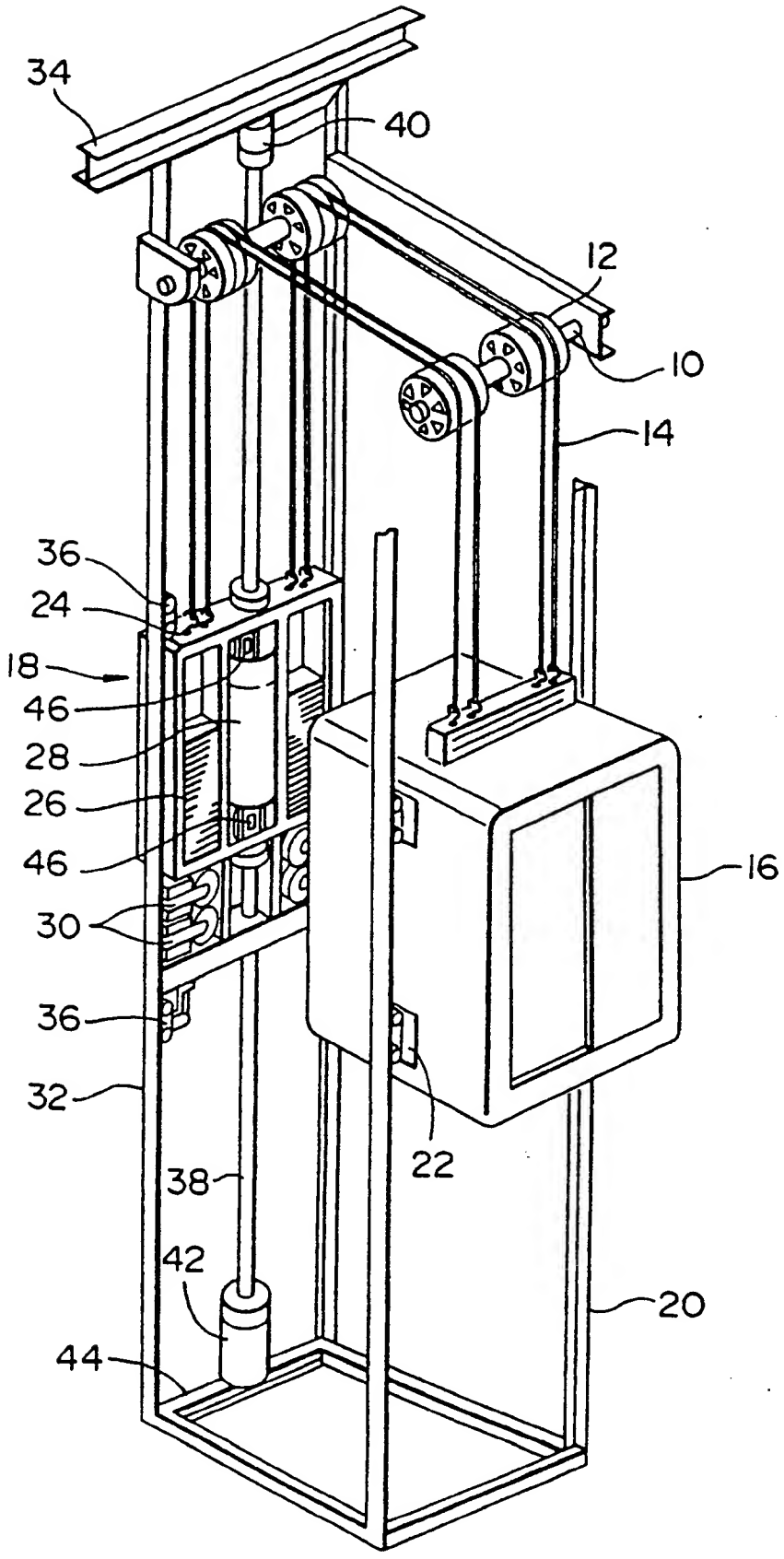

FIG. 1

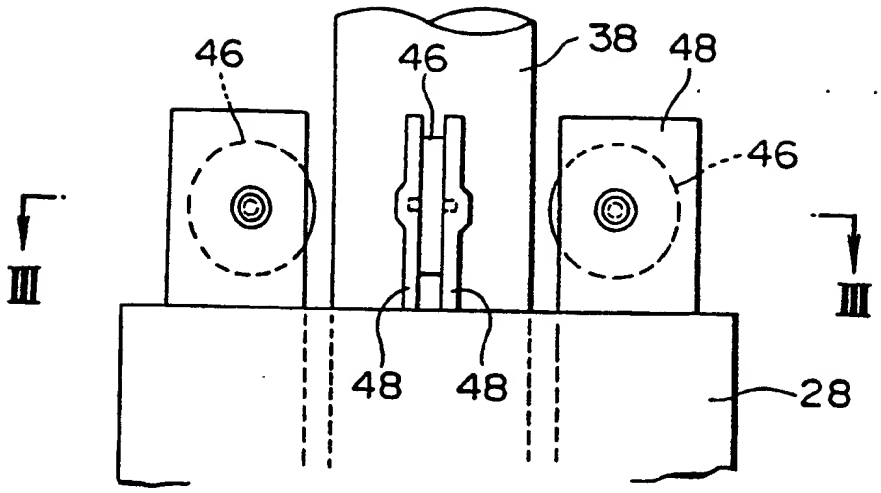

FIG. 2

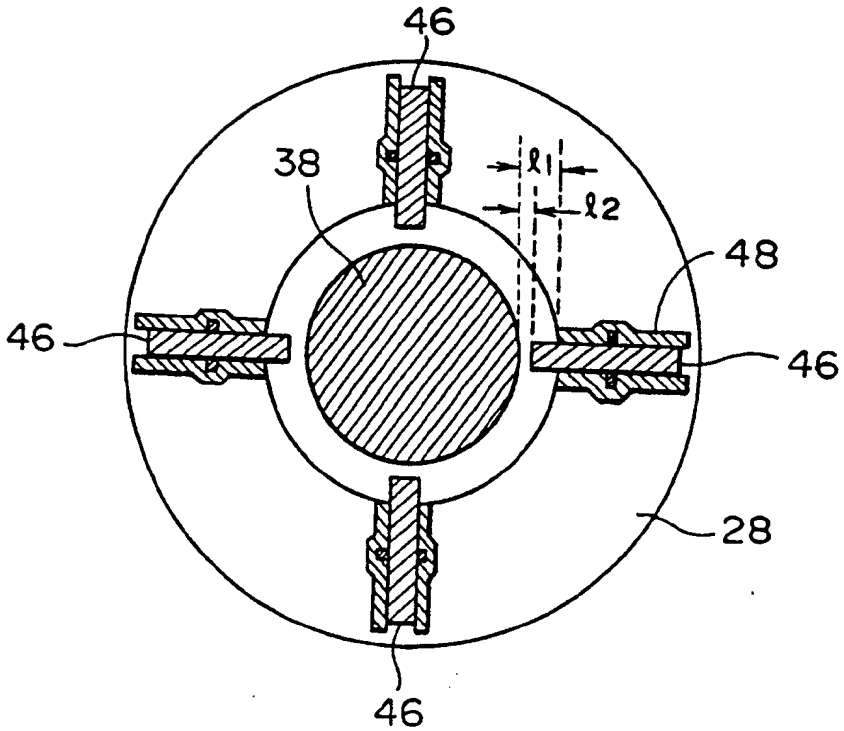

FIG. 3

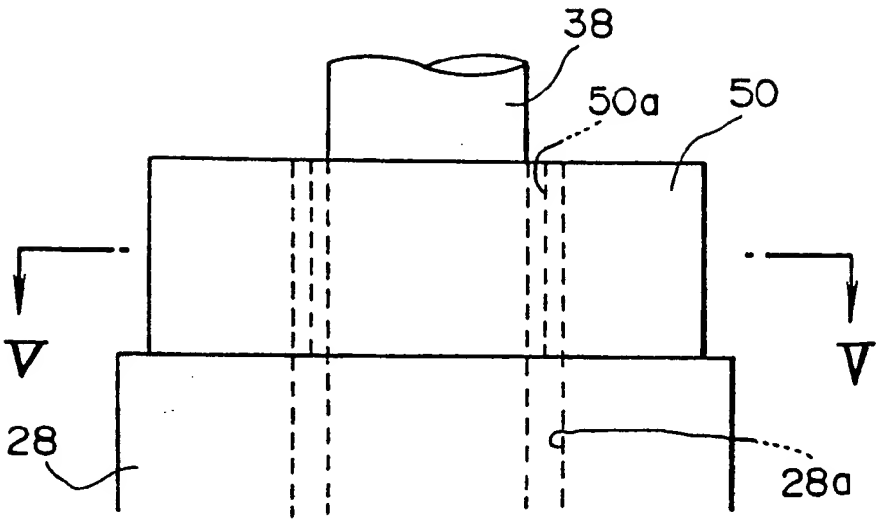

FIG. 4

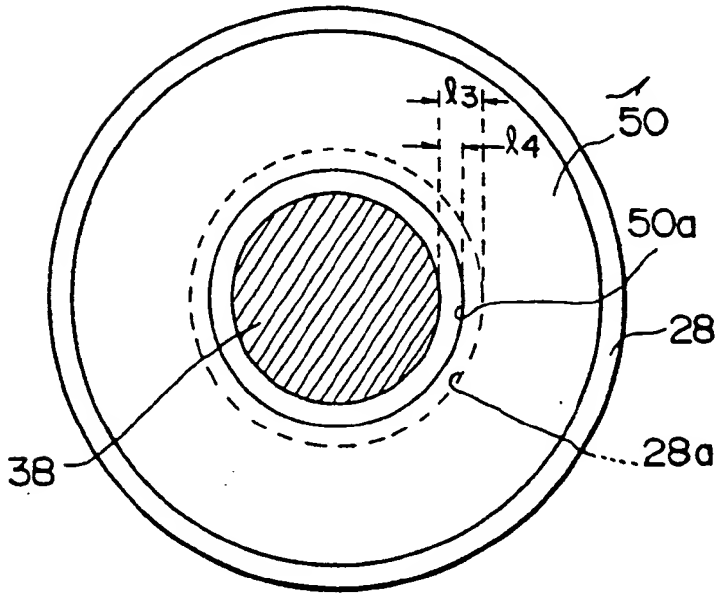

FIG. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 10 3353

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-2640955 (F.C.FISHER) * column 3, lines 8 - 16; figure 5 *	1-3	H02K41/02
A	PATENT ABSTRACTS OF JAPAN vol. 5, no. 141 (E-73)(813) 05 September 1981, & JP-A-56 074082 (FUJITSU K.K.) 19 June 1981, * the whole document *	1, 4	
A	PATENT ABSTRACTS OF JAPAN vol. 8, no. 161 (E-257)(1598) 26 July 1984, & JP-A-59 059063 (FUJITSU K.K.) 04 April 1984, * the whole document *		
A	US-A-4215283 (W.E.HINDS) * figure 2 *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H02K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	11 MAY 1990	LEOUFFRE, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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